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Ferric-gum photography - Exploring the role of iron(III) salts in the hardening of gum arabic

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Chemical Interactions of Ferric Chloride

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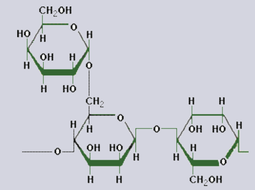


Ferric Gum photographic process

For over a century, photography relied on photochemical reactions of silver salts to produce images. However, the reactions of other photosensitive salts containing iron or chromium have also been used to generate photographs as far back as the 1840s. These “alternative” photographic processes have been reutilized by modern photographers who are interested in making one-of-a-kind prints from digitally-captured images.

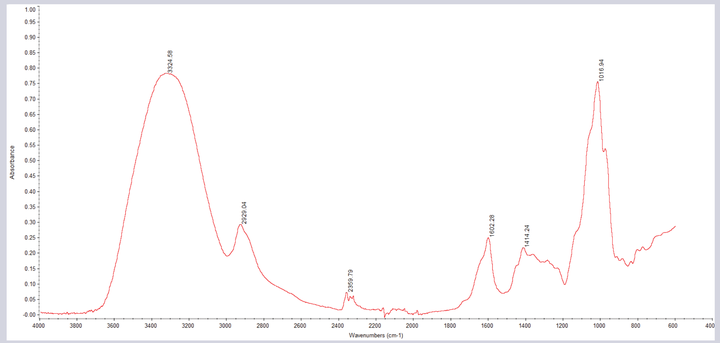
The science of many alternative methods has long been overlooked with few reported studies of the chemistry underlying them. The ferric-gum photographic development technique is one such process. It relies on the hardening of the binder in watercolor paint (gum Arabic) as it interacts with a salt called ferric chloride ($FeCl_3$). Prior to applying the paint, the paper is saturated with an aqueous solution of ferric chloride and allowed to dry; then it is exposed to ultraviolet light through a transparency of a digitally-recorded image. This produces a faint image due to the reduction of Fe^{3+} ions to Fe^{2+} in the paper.

As watercolor paint was applied to the paper, a hardened film was formed where the gum arabic contacted the unbleached ferric chloride.

Infrared Spectroscopy

To better understand the interaction between ferric ions and gum arabic, we prepared paper samples saturated with various ferric salts, coated them each with a suspension of gum arabic, and measured their absorbance of infrared light.

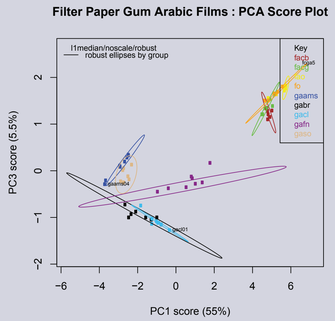
This type of analysis, called infrared spectroscopy, provides us with information about the chemical bonding within the gum arabic and any changes in that bonding produced by the presence of ferric salts. When a sample interacts light in the infrared region of the electromagnetic spectrum, quantified amounts of energy are absorbed and cause vibrations in specific bonds in a molecule.

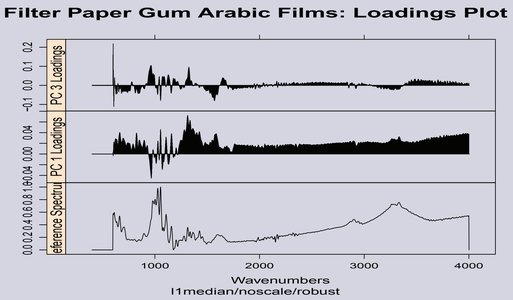


Principal Component Analysis

Principal component analysis is a statistical technique that identifies patterns in large data sets. These patterns are revealed using “constructed” vectors called principal components (PCs). The technique determines scores for each original spectrum that are then plotted along these principal components. These are called score plots.

We found the most segregation on principal components 1 and 3. This was followed by looking at the loadings for principal components 1 and 3, which allowed us to identify the differences in the spectra causing the statistical differences.





The loadings on PC1 show differences in the 900-1200 cm^{-1}. This is consistent with the visual observation of the films shown below. The film on the left (inorganic anion salt) shows formation of a gum arabic film on the paper; the film on the right (organic anion salt) shows no such film formation. The loadings on PC3 have proven harder to interpret, but show interesting behaviour in the 1500-1800 cm^{-1} and 2900-3600 cm^{-1} ranges.